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Growth, Flowering and Fruiting of Manzanillo Olive Trees as Affected by Benzyladenine

[1]A.B. Abou Aziz, [2]E.S. Hegazi, [2]T.A. Yehia, [1]Nabila E. Kassim and [1]Thanaa Sh. M. Mahmoud

[1]Department of Horticultural Crops Technology, National Research Center, Dokki, Giza, Egypt
[2]Department of Pomology, Faculty of Agriculture, Cairo University, Giza, Egypt

Abstract: This investigation was carried out to evaluate the effect of foliar application of benzyladenine (BA) at concentration 10, 20, 30 and 40 ppm on growth, photosynthetic pigments, mineral status, total carbohydrates content, flowering, fruiting characteristics, yield/tree and oil content of Manzanillo olive trees. The experiment was performed during seasons 2009 and 2010 in a private orchard located at Cairo - Alexandria, desert road, Egypt (about 50 Km from Cairo). Different concentrations of benzyladenine (BA) were applied twice at the stage of swelling buds and six weeks later. Results obtained showed that all the applied treatments significantly increased vegetative growth characteristics (leaf area, leaf dry weight and specific leaf weight) compared to the control trees in both seasons of the study. Application of benzyladenine (10, 20, 30 and 40ppm) significantly increased photosynthetic pigments in leaves (chlorophyll a, chlorophyll b and total chlorophyll). Benzyladenine application significantly increased leaf P, K and Mg content, whereas leaf N % was not significantly affected in both seasons. Total carbohydrate contents were significantly increased with BA. The highest total carbohydrates content was resulted from higher concentration (40 ppm) in the two successive seasons. All studied parameters of flowering characteristics were significantly increased by spraying BA at all investigated rates over the control. Similarly significant improvements were attained in fruit characteristics as a result of the applied treatments. Results are presented for the studied fruit characteristics which comprised of average weight, size, length, diameter, pulp/seed ratio and fruit moisture content as a result of the applied treatments during the two studied seasons. Increasing concentration of benzyladenine from 10 to 40 ppm was accompanied with significant increase in yield (kg/tree). Foliar application of benzyladenine (BA) significantly increased the oil content in the two seasons compared with the control. It can be recommended from the present study that the application of different concentrations of benzyladenine on Manzanillo olive trees caused significant improvement in growth, photosynthetic pigments concentrations, mineral status, total carbohydrates content, fruit set, yield and most of the studied fruit characteristics and oil content. However, most of the previous characteristics were increased with increasing benzyladenine treatment from 10 to 40 ppm.

Key words: Olive · Manzanillo · Cytokinins · Benzyladenine · Growth · Leaf mineral · Carbohydrate · Photosynthetic pigments · Flowering · Fruit characteristics · Yield and oil content

INTRODUCTION

Olive (*Olea europaea* L.) is considered one of the important fruit crops in Egypt. The total acreage reached about 158058 feddans (one feddan=4200m^2) in 2009 of which 110175 feddans are in fruitful stage, with total production of about 449009 ton [1]. In Egypt, olive cultivation has an important role in agricultural products since; it increases the land value especially in unsuitable soil for other fruit crops due to its capability to grow under several conditions.

Change from vegetative to flower buds is a complex process regulated by many factors and can be influenced by application of plant growth regulators. Studies of exogenous applications of various plant growth regulators (PGRs) and analysis of endogenous phytohormones showed that PGRs play important roles in floral development [2]. Many experiments show the direct involvement of different growth regulators in promoting or inhibiting flower bud induction and differentiation. However, all these studies relate to the effect of a single regulator or its quantitative change before,

Corresponding Author: Thanaa, Sh. M. Mahmoud, Department of Horticultural Crops Technology, National Research Center, Dokki, Giza, Egypt.

during or after flower bud induction. Cytokinins are important plant hormones that regulate various processes of plant growth and development including cell division and differentiation, enhancement of leaf expansion and nutrient mobilization in high value horticultural crops to increase yield, enhance crop quality and management [3]. Increase in cytokinins during the induction period possibly has a positive effect on floral formation [4]. Cytokinin levels may have a positive effect on flower formation in olive during the induction and initiation periods. Unlike deciduous fruits with a short induction-to-initiation cycle, induction in olive may take up to 8 months, starting as early as July until about 6 weeks after full bloom, later in February. Although floral initiation occurs in November, the process of developing of visible flower parts does not start until March. Differentiation takes place in late February and bloom in May when the formation of each flower part occurs in the inflorescence [5]. Applying growth regulators especially cytokinin may modify morphological and physiological characteristics of plant and may also induce better adaptation of plant to environment through improve the growth and improve yield by increasing fruit set, fruit number and size. Improvement in vegetative growth and yield attributes may enhance crop productivity. Productivity in horticultural systems is often dependent on manipulation of physiological activities of the crop by chemicals means [6].

Benzyladenine (BA) is one of the most active cytokinins, which regulates various growth processes in plant and improve yield and chemical constituents of many crops and recently, BA has been identified as a natural cytokinin in a number of plants. Nevertheless, physiological responses to BA application may be associated with increased endogenous cytokinin concentrations [7]. Probably benzyladenine as a cytokinin compound delayed the senescence stages of buds and increased the entrance of photosynthetic compounds, hormones and other metabolites to inflorescence buds, which are so important for preventing bud abscission and increased the fruit set [8].

Therefore, the present investigation was carried out to investigate the influence of different concentrations of BA at the stage of swelling buds and six weeks later on growth, photosynthetic pigments concentrations, mineral status, total carbohydrates content, flowering, fruiting characteristics, yield/trees and oil content of Manzanillo olive trees.

MATERIALS AND METHODS

This study was carried out during two successive seasons 2009 and 2010 on ten years old Manzanillo olive trees, planted at 5x5 m in sandy soil in a private orchard located at Cairo- Alexandria, desert road, Egypt (about 50 Km from Cairo). Trees were of normal growth, uniform in vigour and received normal fertilization and cultural practices as scheduled in the program of the orchard. The experiment followed complete randomized block design on 15 trees as 5 treatments were applied. Each tree was considered a replicate, three replicates trees per each treatment. The trees were sprayed twice at the stage of swelling buds and six weeks later with freshly prepared solutions of benzyladenine (BA) at the rate of 10, 20, 30 and 40 ppm using 5 litters of solution respectively for each experimental tree additional to the control (sprayed with water only).Triton B was used as a wetting agent.

The effect of the previous treatments was studied by evaluating their influence on the following parameters:

Vegetative Growth

Leaf Area: At mid. July of each season, leaf area (cm^2) was determined as average of twenty leaves from the middle portion of the tagged shoots on each replicate tree using leaf area meter ,Li-Cor model Li-2000 Ano Pam 167.

Leaf Dry Weight (LDW): Leaves were dried in the electric oven at 70°c for 48 h until constant weight, measured and used to calculate LDW.

Specific Leaf Dry Weight: Specific leaf dry weight (SLW) mg/cm^2 from the following equation according to Yehia [9] as the following equation:

$$\text{Specific leaf dry weight} = \text{Leaf dry weight (g)} \times 1000/\text{Leaf area } (cm^2)$$

Flowering

Flowering Density (Average Number of Inflorescences/m): On each replicate tree twenty shoots distributed on different sides were chosen randomly and tagged at the beginning of the growing season. All inflorescences on each shoot were counted and recorded to estimate as average number of inflorescences per meter.

Average Number of Perfect Flowers: Percentage of perfect flowers (expressed as percentage of perfect flowers to total number of flowers) according to Hegazi and Stino [10]. One hundred inflorescences were collected randomly from each replicate to estimate average number of perfect flowers/inflorescences.

Fruiting

Initial Fruit Set: Three weeks after full bloom initial fruit set percentage on replicate trees of the studied treatments was calculated from the following equation according to Yehia [11] as the following equation:

Initial fruit set (%) = FR x 100/AVF x ANF

Where: FR = Number of fruit/m, AVF= Average number of perfect flowers/inflorescences. ANF=Average number of inflorescences /m

Final Fruit Set: After sixty days from flowering, final fruit set percentage was calculated in the same sequence mentioned above for the initial fruit set percentage.

Yield: At maturity stage (early October), fruits of each replicate tree were separately harvested, then weighted and yield as Kg/tree was estimated.

Physical Fruit Characteristics: Samples of 20 fruits from each replicate tree i.e. 60 fruits from each of the applied treatments were picked randomly at harvest to determine:

- Average fruit weight (g).
- Average fruit size (cm^3).
- Specific gravity (g /cm^3).
- Average fruit length (cm).
- Average fruit diameter (cm).
- Fruit shape index (L/D ratio).
- Percentage of pulp/seed.

Chemical Fruit Characteristics

Fruit Moisture Percentage: For each replicate a proportional sample of fruit was dried at 60°C in electric air dried oven until constant weight is obtained. Then fruit moisture content was calculated according to Hegazi [12].

Fruit Oil Content: Fruit oil content as a dry weight was determined according to A.O.A.C [13] method by extraction the oil from the dried flesh fruit with Soxhelt apparatus for extraction using petroleum ether 40-60°C of boiling point.

Chemical analysis

Photosynthetic Pigments Content: Photosynthetic pigments (chlorophyll a and chlorophyll b as mg/g) content in fresh leaves was determined using spectrophotometer in 100% acetone extract at wave length 662, 644 nm for chlorophyll a and chlorophyll b, respectively according to Gavrilenko and Zigalova [14].

Leaf Mineral Content: Leaf mineral content at mid. July of each season, twenty leaves from the middle portion at one year old shoot each replicate tree were taken, washed with tap water then with distilled water, dried at 70°c until constant weight, ground and finally digested by using the method of Piper [15]. The digested solution was used to determine: Nitrogen percentage was determined in the dry weight using the micro-kjeldahl. Phosphorus was determined calorimetrically. Potassium was determined by flame photometer. Magnesium was determined by using atomic absorption.

Total Carbohydrates Percentage: Leaf total carbohydrates percentage was extracted and determined according to the method described by Malik and Singh [16].

Statistical Analysis: All obtained data during both 2009 and 2010 experimental seasons were subjected to analysis of variances according to Snedecor and Cochran [17] using (SAS/STAT). Least significant difference (L.S.D) was used to compare between means of treatments according to Waller and Duncan [18] at probability of 5%.

RESULTS AND DISCUSSION

Vegetative Growth: It is obvious from Table 1 that vegetative growth characteristics were influenced significantly as a result of foliar applications with benzyladenine (BA) during both seasons of the study. Leaf area was significantly increased by all foliar application with benzyladenine treatment in both seasons. BA (40 ppm) attained the highest significant leaf area (3.91 and 3.90 cm^2), while control treatment gave the lowest significant value (3.59 and 3.62 cm^2) in the first and second seasons, respectively. Regarding leaf dry weight, results showed that all treatments significantly increased leaf dry weight at both seasons. Foliar application of 40 ppm benzyladenine recorded the highest significant leaf dry weight (1.83 and 1.94g), whereas the lowest significant value was obtained from the control trees (1.57 and 1.55g) in both seasons, respectively. It is worthy to mention that foliar application with benzyladenine caused significant stimulatory effect on specific leaf weight compared with control treatment. Application 40 ppm of benzyladenine gave the highest significant values (4.68 and 4.98 mg/cm^2) in comparison with the lowest concentration (10ppm) or untreated trees during both seasons of the study.

Table 1: Effect of benzyladenine on leaf area, leaf dry weight, specific leaf weight during 2009 and 2010 seasons

	Leaf area (cm^2)		Leaf dry weight (g)		Specific leaf weight (mg/cm^2)	
Treatments	2009	2010	2009	2010	2009	2010
Control	3.59c	3.62c	1.57d	1.55d	4.35b	4.29e
BA 10 ppm	3.77b	3.80b	1.64cd	1.75c	4.35b	4.53d
BA 20 ppm	3.87a	3.88a	1.69cb	1.76bc	4.37b	4.60c
BA 30 ppm	3.89a	3.90a	1.75ab	1.80b	4.51ab	4.61b
BA 40 ppm	3.91a	3.90a	1.83a	1.94a	4.68a	4.98a

Means in each column with similar letters are not significantly different at 5% level

Table 2: Effect of benzyladenine on photosynthetic pigments during 2009 and 2010 seasons

	Chlorophyll(a) (mg/g leaf fresh weight)		Chlorophyll(b) (mg/g leaf fresh weight)		Total chlorophyll (a+b) (mg/g leaf fresh weight)	
Treatments	2009	2010	2009	2010	2009	2010
Control	1.38e	1.44e	2.96c	2.91e	3.12d	3.22c
BA 10 ppm	1.50d	1.53d	3.24b	3.20d	3.19c	3.30b
BA 20 ppm	1.58c	1.65c	3.28b	3.34c	3.21c	3.31b
BA 30 ppm	1.66b	1.69b	3.34ab	3.54b	4.33b	4.53a
BA 40 ppm	1.75a	1.78a	3.46a	3.63a	4.40a	4.51a

Means in each column with similar letters are not significantly different at 5% level.

The increase in the vegetative growth characteristics by benzyladenine treatment could be due to stimulating dry mass production through enhancement of cell division and chlorophyll accumulation which leads to higher photosynthetic activity and accumulation of dry matter. This in turn was reflected on the increasing in translocation and accumulation of certain microelements in plant organs and subsequently on their growth characteristics.

Photosynthetic Pigments: The effect of foliar application with benzyladenine treatment on photosynthetic pigments concentrations of Manzanillo leaves were presented in Table 2. The results showed that photosynthetic pigments, chlorophyll a, b and total chlorophyll (a+b) concentrations were significantly increased by all foliar application with benzyladenine in both seasons 2009 and 2010 as compared to those of control. The highest significant chlorophyll a, b and total chlorophyll (a+b) were obtained as a result of the concentration (40 ppm) benzyladenine as it averaged (1.75, 3.46 and 4.40 mg/g) in 2009 season, respectively and (1.78, 3.63 and 4.53 mg/g) in 2010 season, respectively. The lowest significant chlorophyll a, b and total chlorophyll (a + b) resulted from the control trees as it averaged (1.38, 2.96 and 3.12 mg/g) in 2009 season, respectively and (1.44, 2.91 and 3.22 mg/g) in 2010 season, respectively. In this respect Gintare *et al.* [19] observed that benzyladenine increased leaf chlorophyll content by a strong retardation of the leaf senescence by retarding the terminal changes in chlorophyll or by preserving much of the chlorophyll.

Leaf Minerals Content: The influence of foliar application with benzyladenine treatments on N, P, K and Mg concentrations in leaves is presented in Table 3. Nitrogen content in the leaves was not significantly affected by foliar application with benzyladenine treatments during both seasons of the study. At the first season, highest significant phosphorus % averaged (0.15 %) resulted from application of benzyladenine (40 ppm).Whereas, no significant differences were found between (30, 20, 10 ppm and control). Concerning second season, phosphorus content in the leaves was influenced significantly as a result of different concentrations of benzyladenine treatments; it is obvious that the highest significant phosphorus % was attained as a result of benzyladenine application at (40 ppm) compared to the control trees which recorded the lowest significant value (0.04%) (Table 3). Data also in Table 3 indicated that foliar application of Manzanillo olive trees with benzyladenine at all concentrations led to obvious significant increase in the leaf potassium content. The highest significant values were obtained from the concentration (40 ppm) of benzyladenine in both two seasons (1.23 and 1.24%), respectively. Meanwhile, leaf potassium content in the control trees were the (1.04 and 1.09 %), respectively. Data presented in Table 3 clearly showed that foliar application with benzyladenine treatments significantly increased magnesium content in the leaves compared with control treatment. Application of 40 ppm of benzyladenine gave the highest significant values (20.16 and 14.69 ppm), whereas the lowest significant magnesium content was obtained in the control trees (10.29 and 9.36 ppm)

Table 3: Effect of benzyladenine on some leaf mineral content, total carbohydrate and C/N ratio of Manzanillo olive trees during 2009 and 2010 seasons

	N %		P %		K %		Mg %		Total carbohydrate %		C/N ratio	
Treatments	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
Control	0.11a	0.12a	0.05b	0.04c	1.04c	1.09d	10.29c	9.36c	8.73b	9.14b	80.17a	75.56a
BA 10 ppm	0.11a	0.12a	0.05b	0.06cb	1.08cb	1.15c	12.72c	10.15c	9.72b	9.61b	83.40a	77.91a
BA 20 ppm	0.12a	0.14a	0.06b	0.10ab	1.10cb	1.18cb	13.76cb	10.81bc	10.41ab	12.24a	83.99a	84.35a
BA 30 ppm	0.13a	0.15a	0.08b	0.11a	1.17ab	1.21ab	18.73ab	12.41b	10.98ab	12.30a	85.62a	86.71a
BA 40 ppm	0.14a	0.15a	0.15a	0.14a	1.23a	1.24a	20.16a	14.69a	12.38a	12.76a	89.11a	88.10a

Means in each column with similar letters are not significantly different at 5% level

Table 4: Effect of benzyladenine on flowering of Manzanillo olive trees during 2009 and 2010 seasons

	Flowering density (number of inflorescences/m)		Perfect flowers %		Initial fruit set %		Final fruit set %	
Treatments	2009	2010	2009	2010	2009	2010	2009	2010
Control	12.00b	10.00b	59.67a	55.00c	6.90c	6.74c	3.20c	3.04c
BA 10 ppm	18.23ab	15.33b	71.00a	72.33b	8.89cb	7.42c	5.97b	4.39c
BA 20 ppm	20.46ab	22.59a	73.00a	74.33ab	9.01cb	8.99b	6.53b	6.15b
BA 30 ppm	22.66ab	26.28a	78.33a	82.33ab	10.36ab	10.14b	8.19a	7.79b
BA 40 ppm	24.33a	28.00a	83.67a	86.66a	11.54a	12.33a	9.52a	10.15a

Means in each column with similar letters are not significantly different at 5% level.

during 2009 and 2010 seasons, respectively. The above results are in agreement with those obtained by Stylianidis *et al*. [20] who reported that benzyladenine (50-300 mg/l) and kinetin (50, 100 and 150 mg/l) increased nutrient elements in apple leaves.

Total Carbohydrate Content: It is obvious from Table 3 that total carbohydrate content was influenced by foliar application with benzyladenine treatments during both seasons of the study. Application of benzyladenine with different concentrations was favorable for accumulation of carbohydrates in leaves compared with the control. The highest significant total carbohydrate content was obtained from the concentration (40 ppm) of benzyladenine (12.38 and 12.76 %), whereas the lowest significant total carbohydrate content resulted from the control trees (8.73 and 9.14 %) in 2009 and 2010 seasons, respectively. It can be suggested that application of growth regulators especially benzyladenine encourages the absorption of nitrogen from the soil and/or activated the photosynthetic process through their influence on some enzymatic action. The activation of these processes might cause the increase in carbohydrate percentage. Also, may be due to the stimulation and enhancement of cell division and chlorophyll accumulation and enhancement of growth and increase soluble sugar accumulation [21].

Flowering

Flowering Density: Data in Table 4 illustrated that flowering density expressed as number of inflorescences/m was significantly increased as a result of foliar application with benzyladenine treatments compared with the control during both seasons of the study. The highest significant flowering density was obtained from the concentration (40 ppm) of benzyladenine (24.33 and 28/m), whereas the lowest significant number of inflorescences/m in both seasons were obtained in the control (12 and 10/m) during 2009 and 2010 seasons, respectively.

Percentage of Perfect Flowers: Data in Table 4 showed that percentage of perfect flowers was significantly increased due to application with benzyladenine treatments. The highest significant percentage of perfect flowers was obtained from the concentration (40 ppm) (83.67 and 86.66 %), whereas the lowest significant percentage of perfect flowers was obtained in the control (59.67 and 55 %) during 2009 and 2010 seasons, respectively.

Percentage of Initial Fruit Set: It is evident through results in Table 4 that percentage of initial fruit set was significantly increased as a result of application with benzyladenine treatments. The highest significant percentage of initial fruit set was obtained from the concentration (40 ppm) (11.54 and 12.33%), whereas the lowest significant percentage of initial fruit set in both seasons was obtained in the control averaged (6.90 and 6.74%) during 2009 and 2010 seasons, respectively.

Table 5: Effect of benzyladenine on fruit physical characteristics of Manzanillo olive trees during 2009 and 2010 seasons.

Treatments	Control		BA 10 ppm		BA 20 ppm		BA 30 ppm		BA 40 ppm	
Parameters	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
Fruit weight (g)	3.76d	3.71b	3.93cd	3.96b	4.3bc	4.05b	4.73b	5.17a	5.8a	5.69a
Fruit size (cm^3)	4.07c	4.22d	4.27c	4.46c	4.8b	4.72b	5.03b	5.03b	5.5a	5.1a
Specific gravity (g/cm^3)	0.92bc	0.87c	0.92bc	0.88c	0.89c	0.85cd	0.94b	1.02b	1.05a	1.11a
Fruit length (cm)	2.03c	2d	2.06c	2.15c	2.2c	2.22bc	2.5b	2.32b	2.76a	2.84a
Fruit diameter (cm)	1.52d	1.5c	1.53cd	1.6bc	1.63c	1.62bb	1.8b	1.65b	2a	1.99a
Fruit shape L/D	1.33a	1.33a	1.34a	1.34a	1.34a	1.37a	1.38a	1.4a	1.38a	1.42a
Pulp /seed %	64.66d	70.33c	72.66c	78.66b	78.00b	83.66b	81.33b	84.33ab	88.33a	84.66a

Means in each column with similar letters are not significantly different at 5% level

Percentage of Final Fruit Set: Data presented in Table 4 revealed that application with benzyladenine (40 ppm) recorded the highest significant values of percentage of final fruit set (9.52 and 10.15%), whereas control treatments recorded the lowest significant percentage of final fruit set in this respect; since it gave 3.20 and 3.04 % in the first and second seasons, respectively. The previous results are in harmony with that obtained by Hegazi and Stino [22] on olive Picual cv. who reported that the bud burst, flower bud formation and percentage of perfect flowers was significantly increased by kinetin 100 mg/L. It can be suggested that the high concentrations of certain cytokinin levels may have a positive effect on flower formation in olive during the induction and initiation periods [23]. Moreover, probably benzyladenine as a cytokinin compound delayed the senescence stages of buds and increased the entrance of photosynthetic compounds, hormones and other metabolites to inflorescence buds, which are so important for preventing bud abscission and increased the fruit set [8].

Fruit Physical Characteristics: Almost all the applied treatments significantly improved physical characteristics of Manzanillo olive fruits compared to those of the control trees. However there were significant differences in the enhancement effects of the applied treatments (Table 5).

Fruit Weight: During both seasons highest significant fruit weight (5.80 and 5.69 g) resulted from the concentration (40 ppm) of benzyladenine. Meanwhile, the lowest significant average fruit weight was produced from control trees as it reached only (3.76 and 3.71g) in both seasons.

Fruit Size: The highest significant fruit size reached (5.50 and 5.10 cm^3) in 2009 and 2010 seasons. The highest levels were observed as a result of application of benzyladenine (40 ppm) in both seasons (Table 5), whereas the lowest significant fruit size resulted from the control trees and reached (4.07 and 4.22 cm^3) during seasons 2009 and 2010, respectively.

Fruit Specific Gravity: The highest significant fruit specific gravity was noticed as a result of BA (40 ppm) in both seasons of the study. Meanwhile the lowest significant resulted from the concentration (20 ppm) of benzyladenine (Table5). The highest values of specific gravity (1.05 and 1.12) and lowest (0.89 and 0.85) were obtained during seasons 2009 and 2010, respectively.

Fruit Length: The highest significant fruit length (2.76 and 2.84 cm) was obtained in 2009 and 2010 seasons, respectively. The highest values were observed as a result of application with benzyladenine (40 ppm) (Table 5), whereas the lowest significant fruit length was resulted from the control trees and reached (2.03 and 2.00 cm) during 2009 and 2010 seasons, respectively.

Fruit Diameter: The highest significant fruit diameter (2.00 and 1.99 cm) was obtained in seasons 2009 and 2010, respectively. The highest values were observed as a result of application with benzyladenine (40 ppm), whereas the lowest significant fruit diameter resulted from the control trees and reached (1.52 and 1.50 cm) during 2009 and 2010 seasons, respectively.

Fruit Shape: Fruit shape involves fruit length, diameter and fruit shape index (L/D ratio) (Table 5). Foliar application of 40 ppm of benzyladenine gave the highest values of fruit length (2.76 and 2.84 cm) and also the highest significant values of fruit diameter (2 and 1.99 cm). Meanwhile fruit shape was not significantly affected by the treatments. However the lowest fruit shape index was resulted from the control trees (1.33) in the 2009 and 2010 seasons, respectively.

Table 6: Effect of benzyladenine on fruit chemical characteristics and yield of Manzanillo olive trees during 2009 and 2010 seasons

	Fruit moisture content		Oil (%)		Yield (Kg/ tree)		
Treatments	2009	2010	2009	2010	2009	2010	Mean
Control	77.00b	74.66c	14.66a	17.00b	15.33c	18.00c	17c
BA 10 ppm	83.66a	78.00cb	15.33a	18.00ab	17.66cb	21.66cb	20cb
BA 20 ppm	83.66a	81.33ab	16.66a	18.66ab	21.33ab	25.33ab	23ab
BA 30 ppm	84.33a	83.00a	17.33a	19.0ab	25.00a	26.33a	26a
BA 40 ppm	85.33a	83.00a	18.16a	19.98a	25.00a	28.66a	27a

Means in each column with similar letters are not significantly different at 5% level

Pulp/seed Ratio: Foliar application of 40 ppm benzyladenine resulted in the highest significant pulp/seed ratio (88.33 and 84.66%), while the lowest significant levels of pulp/seed ratio (64.66 and 70.33 %) was recorded with control treatment in 2009 and 2010 seasons, respectively. Fruit growth after bloom is dependent in large part on photosynthesis supplied by spur leaves [24]. Cytokinins have the ability to promote carbohydrate metabolism and create new source-sink relationships, thus leading to increase fruit size and fruit dry matter [25]. The cytokinin 6-benzyladenine (BA) influenced larger fruit size or weight by increasing number of cells per fruit through the stimulation of cell division and increasing number of cell layers and not cell expansion [26].

Fruit Chemical Characteristics: The effect of the applied treatments was investigated on the most reliable fruit chemical characteristics which involved fruit moisture content and oil content (Table 6). Concerning fruit moisture content in the first season, there were not significant differences between (40, 30, 20 and 10 ppm) treatments. Whereas in the second season, fruit moisture content was influenced significantly as a result of different concentrations of benzyladenine treatments; it is obvious that the highest significant fruit moisture content was attained as a result of benzyladenine application at (40 ppm) compared to the control trees which recorded the lowest significant values. It is obvious from Table 6 that in the first season oil content was not influenced significantly as a result of benzyladenine treatments. Whereas in the second season, oil content significantly increased due to different concentrations of benzyladenine treatments. The highest significant oil content was obtained in the high concentration (40 ppm) of benzyladenine (19.98 %), whereas the lowest significant oil content in the control (17 %).

Yield: Data in Table 6 illustrated that effect of spraying benzyladenine on yield (kg/tree) is considered a reflection of the studied treatments on fruit productivity of the examined trees. Foliar application of 40 ppm benzyladenine during of swelling buds stage and also during six weeks later resulted in the highest significant yield and it averaged (27 kg/tree) compared to the lowest significant yield produced from the control trees averaged (17kg/tree) in the first and second seasons, respectively. The increase in yield could be a reflection of the effect of benzyladenine on growth and development, also it might be due to either marked increase in number of branches/tree which gave a chance to the tree to carry more flowers and hence more fruits or marked increase in the photosynthetic pigments content (Table 2), which could lead to increase in photosynthesis, resulting in greater transfer of assimilates to the fruits and causing increase in their weight (Table 5).These results are in agreement with those obtained by Yehia and Hassan [11] and Bang and Zeng [27] found that foliar application of benzyladenine caused significant increase yield/tree compared to the control. Yield can be improved when the trees are enhanced. This can be achieved by increasing leaf light interception, Co_2 fixation, mineral uptake and reduction in competition for photassimilates and nutrients between the tree organs.

CONCLUSION

From the obtained results, it can be concluded that Manzanillo olive trees greatly respond to application of benzyladenine (40 ppm) at the stage of swelling buds and six weeks later as it increased growth characteristics, photosynthetic pigments concentrations, mineral status, total carbohydrates content, flowering, fruit set, fruit quality, oil content and yield.

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